

CLAIMS

1. An abnormality diagnosis apparatus that diagnoses an abnormality of an adjustable valve mechanism, which varies a moving characteristic of a valve in an internal combustion engine, said abnormality diagnosis device comprising:

a control signal input module that inputs a control signal for varying the moving characteristic of the valve;

a theoretical value computation module that computes a physical behavior of the adjustable valve mechanism according to a physical model and thereby calculates a theoretical value of a parameter relating to the moving characteristic of the valve, which is varied by the adjustable valve mechanism, in response to the input control signal;

an observed value detection module that detects an observed value of the parameter relating to the moving characteristic of the valve, which is varied by the adjustable valve mechanism, in response to the input control signal; and

an abnormality detection module that determines whether the adjustable valve mechanism is abnormal or normal, based on the theoretical value and the observed value.

2. An abnormality diagnosis apparatus in accordance with claim 1, wherein said abnormality detection module determines that the adjustable valve mechanism is abnormal, when a difference between the theoretical value and the observed value is out of a preset range.

3. An abnormality diagnosis apparatus in accordance with claim 1, wherein the adjustable valve mechanism rotates a hydraulic vane fixed to a cam shaft in response to the input control
5 signal, thereby varying an open-close timing of the valve, and

said theoretical value computation module computes the physical behavior of the adjustable valve mechanism according to the physical model, on the assumption that a rotational motion of the hydraulic vane corresponds to a translational motion of
10 a piston.

4. An abnormality diagnosis apparatus in accordance with claim 1, wherein said theoretical value computation module calibrates the theoretical value computed according to the
15 physical model under a specified condition.

5. An abnormality diagnosis apparatus in accordance with claim 1, wherein said theoretical value computation module constructs a linear model of the adjustable valve mechanism and
20 carries out system identification according to the constructed linear model, so as to compute the physical behavior of the adjustable valve mechanism according to the physical model.

6. An abnormality diagnosis apparatus that diagnoses an
25 abnormality of an adjustable valve mechanism, which changes a phase of a cam shaft for opening and closing a valve in an internal combustion engine relative to a crankshaft of the internal

combustion engine and thereby varies an opening-closing characteristic of the valve, said abnormality diagnosis apparatus comprising:

5 a fluid actuator that takes advantage of a pressure difference between two pressure chambers and thereby changes a phase difference between the cam shaft and the crankshaft;

a fluid control valve that switches over a state between a supply and a discharge of a working fluid to and from each of the two pressure chambers of said fluid actuator;

10 a control unit that outputs a control signal to said fluid control valve to switch over the state between the supply and the discharge of the working fluid;

a sensor that actually measures a phase difference between the cam shaft and the crankshaft;

15 a computation module that computes a pressure difference between the two pressure chambers in response to at least the control signal output from said control unit and calculates a phase difference between the cam shaft and the crankshaft from the computed pressure difference; and

20 a determination module that compares the actual phase difference measured by said sensor with the calculated phase difference and determines that at least one of said fluid actuator and said fluid control valve is abnormal when a difference between the calculated phase difference and the measured phase difference
25 is not less than a preset value.

7. An abnormality diagnosis apparatus in accordance with

claim 6, said abnormality diagnosis apparatus further comprising:

a revolution speed sensor that measures a revolution speed of the internal combustion engine,

wherein said computation module comprises a pressure
5 difference computation module that uses an arithmetic expression based on a model constructed with flows of the working fluid in said fluid actuator and said fluid control valve and with a reactive force of the cam shaft, which depends upon the revolution speed of the internal combustion engine and is applied from the
10 cam shaft onto said fluid actuator, and computes the pressure difference between the two pressure chambers with the control signal output from said control unit and the revolution speed of the internal combustion engine as parameters.

15 8. An abnormality diagnosis apparatus in accordance with claim 7, wherein the arithmetic expression used by said pressure difference computation module follows a model, which takes into account leakage of the working fluid between the two pressure chambers.

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9. An abnormality diagnosis apparatus in accordance with either one of claims 7 and 8, wherein the working fluid in said fluid actuator is working oil having a temperature-dependent viscosity,

25 said abnormality diagnosis apparatus further comprising:
an oil temperature sensor that measures temperature of the working oil,

wherein the arithmetic expression used by said pressure difference computation module follows a model, which takes into account the temperature of the working oil that reflects the viscosity of the working oil, and the parameters include the temperature of the working oil measured by said oil temperature sensor.

10. An abnormality diagnosis apparatus in accordance with claim 6, wherein the adjustable valve mechanism rotates a hydraulic vane fixed to the cam shaft in response to the control signal, thereby varying an open-close timing of the valve, and said computation module comprises a pressure difference computation module that computes the pressure difference between the two pressure chambers according to an arithmetic expression, which follows a model constructed on the assumption that a rotational motion of the hydraulic vane corresponds to a translational motion of a piston.

11. An abnormality diagnosis apparatus in accordance with claim 6, wherein said computation module carries out calibration with the computed phase difference under a specified condition.

12. An abnormality diagnosis apparatus in accordance with claim 6, wherein said computation module constructs a linear model of the adjustable valve mechanism and carries out system identification according to the constructed linear model, so as to compute the pressure difference between the two pressure

chambers.

13. An abnormality diagnosis apparatus that diagnoses an abnormality of an adjustable valve mechanism, which varies a moving characteristic of a valve in an internal combustion engine, said abnormality diagnosis apparatus comprising:

a receiver that receives an input control signal for varying the moving characteristic of the valve;

a calculator that computes a physical behavior of the adjustable valve mechanism according to a physical model and thereby calculates a theoretical value of a parameter relating to the moving characteristic of the valve, which is varied by the adjustable valve mechanism, in response to the input control signal;

an observer that observes a value of the parameter relating to the moving characteristic of the valve, which is varied by the adjustable valve mechanism, in response to the input control signal; and

a detector that detects the abnormality of the adjustable valve mechanism, based on the difference between the theoretical value and the observed value.

14. An abnormality diagnosis method that diagnoses an abnormality of an adjustable valve mechanism, which varies a moving characteristic of a valve in an internal combustion engine, said abnormality diagnosis method comprising the steps of:

inputting a control signal for varying the moving

characteristic of the valve;

computing a physical behavior of the adjustable valve mechanism according to a physical model and thereby calculating a theoretical value of a parameter relating to the moving
5 characteristic of the valve, which is varied by the adjustable valve mechanism, in response to the input control signal;

detecting an observed value of the parameter relating to the moving characteristic of the valve, which is varied by the adjustable valve mechanism, in response to the input control
10 signal; and

determining whether the adjustable valve mechanism is abnormal or normal, based on the theoretical value and the observed value.

15 15. An abnormality diagnosis method that diagnoses an abnormality of an adjustable valve mechanism, which changes a phase of a cam shaft for opening and closing a valve in an internal combustion engine relative to a crankshaft of the internal combustion engine and thereby varies an opening-closing
20 characteristic of the valve, said abnormality diagnosis method comprising the steps of:

providing a fluid control valve that switches over a state between a supply and a discharge of a working fluid to and from each of two pressure chambers included in a fluid actuator, which
25 takes advantage of a pressure difference between the two pressure chambers and thereby changes a phase difference between the cam shaft and the crankshaft;

outputting a control signal to said fluid control valve to switch over the state between the supply and the discharge of the working fluid;

actually measuring a phase difference between the cam shaft
5 and the crankshaft with a sensor;

computing a pressure difference between the two pressure chambers in response to at least the control signal;

calculating a phase difference between the cam shaft and the crankshaft from the computed pressure difference; and

10 comparing the actual phase difference measured by the sensor with the calculated phase difference and determining that at least one of the fluid actuator and the fluid control valve is abnormal when a difference between the calculated phase difference and the measured phase difference is not less than a
15 preset value.